SECTION 3

Note: Some figures and tables are not available on the Internet version.

TARGET SPECIES

The primary objectives of this section are to: (1) discuss the purpose of using target species, (2) describe the criteria used to select target species, and (3) provide lists of recommended target species. Target species recommended for freshwater and estuarine/marine ecosystems are discussed in Sections 3.3 and 3.4, respectively.

3.1 PURPOSE OF USING TARGET SPECIES

The use of target species allows comparison of fish, shellfish, and turtle tissue contaminant monitoring data among sites over a wide geographic area. Differences in habitat, food preferences, and rate of contaminant uptake among various fish, shellfish, and turtle species make comparison of contaminant monitoring results within a State or among States difficult unless the contaminant data are from the same species. It is virtually impossible to sample the same species at every site, within a State or region or nationally, due to the varying geographic distributions and environmental requirements of each species. However, a limited number of species can be identified that are distributed widely enough to allow for collection and comparison of contaminant data from many sites.

Three aims are achieved by using target species in screening studies. First, States can cost-effectively compare contaminant concentrations in their State waters and then prioritize sites where tissue contaminants exceed human health screening values. In this way, limited monitoring resources can be used to conduct intensive studies at sites exhibiting the highest degree of tissue contamination in screening studies. By resampling target species used in the screening study in Phase I intensive studies and sampling additional size classes and additional target species in Phase II intensive studies as resources allow, States can assess the magnitude and geographic extent of contamination in species of commercial, recreational, or subsistence value. Second, the use of common target species among States allows for more reliable comparison of sampling information. Such information allows States to design and evaluate their own contaminant monitoring programs more efficiently, which should further minimize overall monitoring costs. For example, monitoring by one State of fish tissue contamination levels in the upper reaches of a particular river can provide useful information to an adjacent State on tissue contamination levels that might be anticipated in the same target species at sampling sites downstream. Third, the use of a select group of target fish, shellfish, and freshwater turtle species will allow for the development of a national database for tracking the magnitude and geographic extent of pollutant contamination in these target species nationwide and will permit analyses of trends in fish, shellfish, and

turtle contamination over time.

3.2 CRITERIA FOR SELECTING TARGET SPECIES

The appropriate choice of target species is a key element of any chemical contaminant monitoring program. Criteria for selecting target species used in the following national fish and shellfish contaminant monitoring programs were reviewed by the EPA Fish Contaminant Workgroup to assess their applicability for use in selecting target species for State fish contaminant monitoring programs:

- National Study of Chemical Residues in Fish (U.S. EPA)
- National Dioxin Study (U.S. EPA)
- 301(h) Monitoring Program (U.S. EPA)
- National Pesticide Monitoring Program (U.S. FWS)
- National Contaminant Biomonitoring Program (U.S. FWS)
- National Status and Trends Program (NOAA).
- National Water-Quality Assessment Program (USGS).

The criteria used to select target species in many of these programs are similar although the priority given each criterion may vary depending on program aims.

The EPA Fish Contaminant Workgroup believes the most important criterion for selecting target fish, shellfish, and turtle species for State contaminant monitoring programs assessing human consumption concerns is that the species are commonly consumed in the study area and are of commercial, recreational, or subsistence fishing value. Two other criteria of major importance are that the species have the potential to bioaccumulate high concentrations of chemical contaminants and have a wide geographic distribution. EPA recommends that States use the same criteria to select species for both screening and intensive site-specific studies.

In addition to the three primary criteria for target species selection, it is also important that the target species be easy to identify taxonomically because there are significant species-specific differences in bioaccumulation potential. Because many closely related species can be similar in appearance, reliable taxonomic identification is essential to prevent mixing of closely related species with the target species. **Note:** Under no circumstance should individuals of more than one species be mixed to create a composite sample (U.S. EPA, 1991e). It is also both practical and cost-effective to sample target species that are abundant, easy to capture, and large enough to provide adequate tissue samples for chemical analyses.

It cannot be overemphasized that final selection of target species will require the expertise of State fisheries biologists with knowledge of local species that best meet the selection criteria and knowledge of local human consumption patterns. Although, ideally, all fish, shellfish, or turtle species consumed from a given waterbody by the local population should be monitored, resource constraints may dictate that only a few of the most frequently consumed species be sampled.

In the next two sections, lists of recommended target species are provided for freshwater ecosystems (inland fresh waters and the Great Lakes) and estuarine/marine ecosystems (Atlantic, Gulf, and Pacific waters), and the methods used to develop each list are discussed.

3.3 FRESHWATER TARGET SPECIES

As part of the two-tiered sampling strategy proposed for State fish contaminant monitoring programs, EPA recommends that States collect one bottom-feeding fish species and one predator fish species at each freshwater screening study site. Some suggested target species for use in State fish contaminant monitoring programs are shown in Table 3-1 for inland fresh waters and in Table 3-2 for Great Lakes waters.

The lists of target species recommended by the EPA Fish Contaminant Workgroup for freshwater ecosystems were developed based on a review of species used in the following national monitoring programs:

- National Study of Chemical Residues in Fish (U.S. EPA)
- National Dioxin Study (U.S. EPA)
- National Pesticide Monitoring Program (U.S. FWS)
- National Contaminant Biomonitoring Program (U.S. FWS)
- National Water-Quality Assessment Program (USGS)

and on a review of fish species cited in State fish consumption advisories or bans (RTI, 1993). Separate target species lists were developed for inland fresh waters (Table 3-1) and Great Lakes waters (Table 3-2) because of the distinct ecological characteristics of these waters and their fisheries. Each target species list has been reviewed by regional and State fisheries experts.

Table 3-1. Recommended Target Species for Inland Fresh Waters

Family name	Common name	Scientific name
Percichthyidae	White bass	*Morone chrysops*
Centrarchidae	Largemouth bass	*Micropterus salmoides*
	Smallmouth bass	*Micropterus dolomieui*
	Black crappie	*Pomoxis nigromaculatus*
	White crappie	*Pomoxis annularis*
Percidae	Walleye	*Stizostedion vitreum*
	Yellow perch	*Perca flavescens*
Cyprinidae	Common carp	*Cyprinus carpio*
Catostomidae	White sucker	*Catostomus commersoni*
Ictaluridae	Channel catfish	*Ictalurus punctatus*
	Flathead catfish	*Pylodictis olivaris*
Esocidae	Northern pike	*Esox lucius*
Salmonidae	Lake trout	*Salvelinus namaycush*
	Brown trout	*Salmo trutta*
	Rainbow trout	*Oncorhynchus mykiss*[a]

[a]Formerly *Salmo gairdneri*.

Table 3-2. Recommended Target Species for Great Lakes Waters

Family name	Common name	Scientific name
Percichthyidae	White bass	*Morone chrysops*
Centrarchidae	Smallmouth bass	*Micropterus dolomieui*
Percidae	Walleye	*Stizostedion vitreum*
Cyprinidae	Common carp	*Cyprinus carpio*
Catostomidae	White sucker	*Catostomus commersoni*
Ictaluridae	Channel catfish	*Ictalurus punctatus*
Esocidae	Muskellunge	*Esox masquinongy*
Salmonidae	Chinook salmon	*Oncorhynchus tschawytscha*
	Lake trout	*Salvelinus namaycush*
	Brown trout	*Salmo trutta*
	Rainbow trout	*Oncorhynchus mykiss*[a]

[a]Formerly *Salmo gairdneri*.

Table 3-4. Freshwater Turtles Recommended for Use as Target Species

Family name	Common name	Scientific name
Chelydridae	Snapping turtle	*Chelydra serpentina*
Emydidae	Yellow-bellied turtle	*Trachemys scripta scripta*
	Red-eared turtle	*Trachemys scripta elegans*
	River cooter	*Pseudemys concinna concinna*
	Suwanee cooter	*Pseudemys concinna suwanniensis*
	Slider	*Pseudemys concinna hieroglyphica*
	Texas slider	*Pseudemys concinna texana*
	Florida cooter	*Pseudemys floridana floridana*
	Peninsula cooter	*Pseudemys floridana penisularis*
Trionychidae	Smooth Softshell	*Apalone muticus*
	Eastern Spiny Softshell	*Apalone spinifera spinifera*
	Western Spiny Softshell	*Apalone spinifera hartwegi*
	Gulf Coast Spiny Softshell	*Apalone spinifera aspera*
	Florida Softshell	*Apalone ferox*

Use of two distinct ecological groups of finfish (i.e., bottom-feeders and predators) as target species in freshwater systems is recommended. This permits monitoring of a wide variety of habitats, feeding strategies, and physiological factors that might result in differences in bioaccumulation of contaminants. Bottom-feeding species may accumulate high contaminant concentrations from direct physical contact with contaminated sediment and/or by consuming benthic invertebrates and epibenthic organisms that live in contaminated sediment. Predator species are also good indicators of persistent pollutants (e.g., mercury or DDT and its metabolites) that may be biomagnified through several trophic levels of the food web. Species used in several Federal programs to assess the extent of freshwater fish tissue contamination nationwide are compared in Table 3-3.

In addition to finfish species, States should consider monitoring the tissues of freshwater turtles for environmental contaminants in areas where turtles are consumed by recreational, subsistence, or ethnic populations. Interest has been increasing in the potential transfer of environmental contaminants from the aquatic food chain to humans via consumption of freshwater turtles. Turtles may bioaccumulate environmental contaminants in their tissues from exposure to contaminated sediments or via consumption of contaminated prey. Because some turtle species are long-lived and occupy a medium to high trophic level of the food chain, they have the potential to accumulate high concentrations of chemical contaminants from their diets (Hebert et al., 1993). Some suggested target turtle species for use in State contaminant monitoring programs are listed in Table 3-4.

The list of target turtle species recommended by the EPA Fish Contaminant

Workgroup for freshwater ecosystems was developed based on a review of turtle species cited in State consumption advisories or bans (RTI, 1993) and a review of the recent scientific literature. The recommended target species list has been reviewed by regional and State experts.

3.3.1 Target Finfish Species

Table 3-7. Principal Freshwater Fish Species Cited in State Fish Consumption Advisories[a]

Family name	Common name	Scientific name	Number of States with advisories [b]
Percichthyidae	**White bass**	***Morone chrysops***	**10**
	Striped bass	*Morone saxatilis*	6
	White perch	*Morone americana*	4
Centrarchidae	**Largemouth bass**	***Micropterus salmoides***	**15**
	Smallmouth bass	***Micropterus dolomieui***	**9**
	Black crappie	***Pomoxis nigromaculatus***	**5**
	White crappie	***Pomoxis annularis***	**2**
	Bluegill	*Lepomis macrochirus*	5
	Rock bass	*Ambloplites rupestris*	3
Percidae	**Yellow perch**	***Perca flavescens***	**8**
	Sauger	*Stizostedion canadense*	4
	Walleye	***Stizostedion vitreum***	**9**
Cyprinidae	**Common carp**	***Cyprinus carpio***	**21**
Acipenseridae	Shovelnose sturgeon	*Scaphirhynchus platorynchus*	1
	Lake sturgeon	*Acipenser fulvescens*	2
Catostomidae	Smallmouth buffalo	*Ictiobus bubalus*	4
	Bigmouth buffalo	*Ictiobus cyprinellus*	4
	Shorthead redhorse	*Moxostoma macrolepidotum*	2
	White sucker	***Catostomus commersoni***	**8**
	Quillback carpsucker	*Carpiodes cyprinus*	2
Ictaluridae	White catfish	*Ictalurus catus*	5
	Channel catfish	***Ictalurus punctatus***	**22**
	Flathead catfish	***Pylodictis olivaris***	**4**
	Black bullhead	*Ictalurus melas*	2
	Brown bullhead	*Ictalurus nebulosus*	7
	Yellow bullhead	*Ictalurus natalis*	2
Sciaenidae	Freshwater drum	*Aplodinotus grunniens*	3
Esocidae	**Northern pike**	***Esox lucius***	**7**
	Muskellunge	***Esox masquinongy***	**4**
Salmonidae	Coho salmon	*Oncorhynchus kisutch*	6
	Chinook salmon	***Oncorhynchus tschawytscha***	**7**
	Brown trout	***Salmo trutta***	**9**
	Lake trout	***Salvelinus namaycush***	**10**
	Rainbow trout	***Oncorhynchus mykiss***[c]	**8**
	Brook trout	*Salvelinus fontinalis*	3
	Lake whitefish	*Coregonus clupea formis*	2
Anguillidae	American eel	*Anguilla rostrata*	6

[a]Species in boldface are EPA-recommended target species for inland fresh waters (see Table 3-1) and the Great Lakes waters (Table 3-2).

[b]Many States did not identify individual species of finfish in their advisories.

[c]Formerly *Salmo gairdneri*.

Source: RTI, 1993.

3.3.1.1 Bottom-Feeding Species

EPA recommends that, whenever practical, States use common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), and white sucker (*Catostomus commersoni*) in that order as bottom-feeding target species in both inland fresh waters (Table 3-1) and in Great Lakes waters (Table 3-2). These bottom-feeders have been used consistently for monitoring a wide variety of contaminants including dioxins/furans (Crawford and Luoma, 1993; U.S. EPA, 1992c, 1992d; Versar Inc., 1984), organochlorine pesticides (Crawford and Luoma, 1993; Schmitt et al., 1983, 1985, 1990; U.S. EPA, 1992c, 1992d), and heavy metals (Crawford and Luoma, 1993; Lowe et al., 1985; May and McKinney, 1981; Schmitt and Brumbaugh, 1990; U.S. EPA, 1992c, 1992d). These three species are commonly consumed in the areas in which they occur and have also demonstrated an ability to accumulate high concentrations of environmental contaminants in their tissues as shown in Tables 3-5 and 3-6. **Note:** The average contaminant concentrations shown in Tables 3-5 and 3-6 for fish collected for the National Study of Chemical Residues in Fish (U.S. EPA, 1992c, 1992d) were derived from concentrations in fish from undisturbed areas and from areas expected to have elevated tissue contaminant concentrations. The mean contaminant concentrations shown, therefore, may be higher or lower than those found in the ambient environment because of site selection criteria used in this study.

In addition, these three species are relatively widely distributed throughout the continental United States, and numerous States are already sampling these species in their contaminant monitoring programs. A review of the database *National Listing of State Fish and Shellfish Consumption Advisories and Bans* (RTI, 1993) indicated that the largest number of States issuing advisories for specific bottom-feeding species did so for carp (21 States) and channel catfish (22 States), with eight States issuing advisories for white suckers (see Table 3-7). Appendix B lists the freshwater fish species cited in consumption advisories for each State.

3.3.1.2 Predator Species

EPA recommends that, whenever practical, States use predator target species listed in Tables 3-1 and 3-2 for inland fresh waters and Great Lakes waters, respectively. Predator species, because of their more definitive habitat and water temperature preferences, generally have a more limited geographic distribution. Thus, a greater number of predator species than bottom feeders have been used in national contaminant monitoring programs (Table 3-3) and these are recommended for use as target species in freshwater ecosystems. Predator fish that prefer relatively cold freshwater habitats include many members of the following families: *Salmonidae* (trout and salmon), *Percidae* (walleye and yellow perch), and *Esocidae* (northern pike and muskellunge). Members of the *Centrarchidae* (large- and smallmouth bass, crappie, and sunfish), *Percichthyidae* (white bass), and *Ictaluridae* (flathead catfish) families prefer relatively warm water habitats. Only two predator species (brown trout and largemouth bass) have been used in all four of the national monitoring programs reviewed (Table 3-3). However, most of the other predator species recommended as target species have been used in at least one national monitoring program.

To identify those predator species with a known ability to bioaccumulate contaminants in their tissues, the EPA Workgroup reviewed average tissue concentrations of xenobiotic contaminants for major predator fish species sampled in the National Study of Chemical Residues in Fish. Unlike the bottom-feeders (common carp, channel catfish, and white suckers), no single predator species or group of predator species consistently exhibited the highest tissue concentrations for the contaminants analyzed (Tables 3-5 and 3-6). However, average fish tissue concentrations for some contaminants (i.e., mercury, mirex, chlorpyrifos, DDE, 1,2,3-trichlorobenzene [123-TCB], and trifluralin) were higher for some predator species than for the bottom-feeders despite the fact that only the fillet portion rather than the whole body was analyzed for predator species. This finding emphasizes the need for using two types of fish (i.e., bottom-feeders and predators) with different habitat and feeding strategies as target species.

The current fish consumption advisories for these predator target species are further justification for their recommended use. As was shown for the bottom-feeder target species, States are already sampling the recommended predator target species listed in Table 3-7. The largest number of States issuing advisories for specific predator species did so for largemouth bass (15), lake trout (10), white bass (10), smallmouth bass (9), brown trout (9), walleye (9), rainbow trout (8), yellow perch (8), chinook salmon (7), northern pike (7), black crappie (5), flathead catfish (4), and muskellunge (4) (RTI, 1993).

Because some freshwater finfish species (e.g., several Great Lake salmonids) are highly migratory, harvesting of these species may be restricted to certain seasons because sexually mature adult fish (i.e., the recommended size for sampling) may make spawning runs from the Great Lakes into tributary streams. EPA recommends that spawning populations not be sampled in fish contaminant monitoring programs. Sampling of target finfish species during their spawning period should be avoided because contaminant tissue concentrations may decrease during this time (Phillips, 1980) and because the spawning period is generally outside the legal harvest period. **Note:** Target finfish may be sampled during their spawning period, however, if the species can be legally harvested at this time.

State personnel, with their knowledge of site-specific fisheries and human consumption patterns, must be the ultimate judge of the species selected for use in freshwater fish contaminant monitoring programs within their jurisdiction.

3.3.2 Target Turtle Species

EPA recommends that, in States where freshwater turtles are consumed by recreational, subsistence, or ethnic populations, States consider monitoring turtles to assess the level of environmental contamination and whether it poses a human health risk. In all cases, the primary criterion for selecting the target turtle species is whether it is commonly consumed. To identify those turtle species with a known ability to bioaccumulate contaminants in their tissues, the EPA Workgroup reviewed turtle species cited in State consumption advisories and those species identified in the scientific literature as having accumulated high concentrations of environmental contaminants.

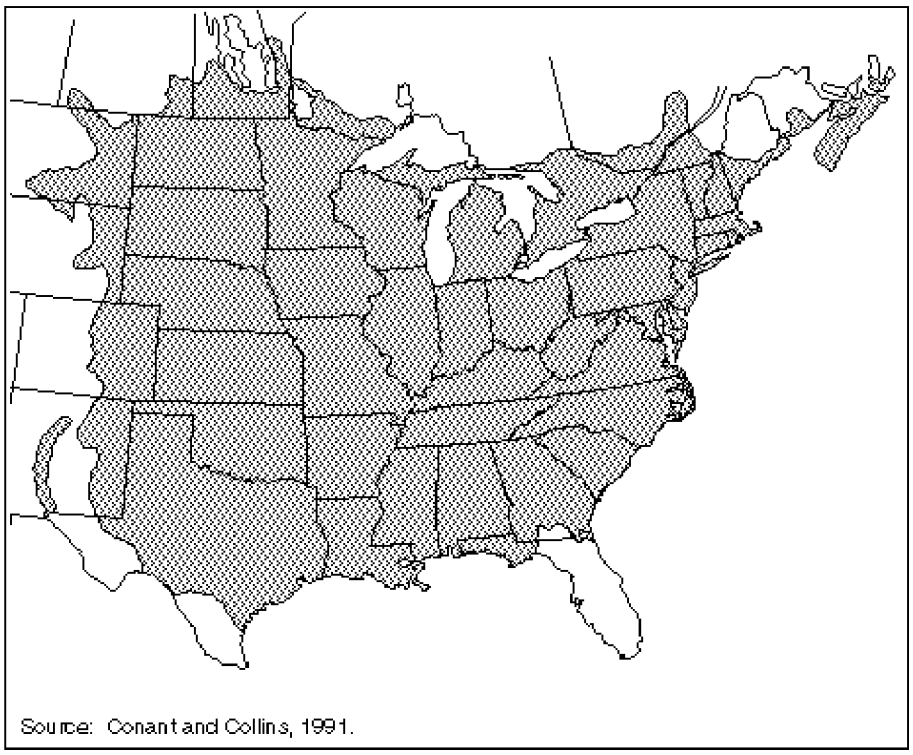

Figure 3-1. Geographic range of the common snapping turtle (*Chelydra serpentina*).

Based on information in State advisories and a number of environmental studies using turtles as biological indicators of pollution, one species stands out as an obvious choice for a target species, the common snapping turtle (*Chelydra serpentina*). This turtle has been recommended by several researchers as an important bioindicator species (Olafsson et al., 1983; Stone et al., 1980) and has the widest geographic distribution of any of the North American aquatic turtles (see Figure 3-1). In addition, this species is highly edible, easily identified, easily collected, long-lived (>20 years), grows to a large size, and has been extensively studied with respect to a variety of environmental contaminants. Other species that should be considered for use as target species are also listed in Table 3-4.

Four States (Arizona, Massachusetts, Minnesota, and New York) currently have consumption advisories in force for various turtle species (New York State Department of Health, 1994; RTI, 1993). The species cited in the State advisories and the pollutants identified in turtle tissues as exceeding acceptable levels of contamination with respect to human health are listed in Table 3-8. New York State has a statewide advisory directed specifically at women of childbearing age and children under 15 and advises these groups to avoid eating snapping turtles altogether. The advisory also recommends that members of the general population who wish to consume turtle meat should trim away all fat and discard the liver tissue and eggs of the turtles prior to cooking the meat or preparing other dishes. These three tissues have been shown to accumulate extremely high concentrations of a variety of environmental contaminants in comparison to muscle tissue (Bryan et al., 1987; Hebert et al., 1993; Olafsson et al 1983; 1987; Ryan et al., 1986; Stone et al., 1980). The Minnesota advisory also recommends that consumers remove all fat from turtle meat prior to cooking as a risk-reducing strategy (Minnesota Department of Health, 1994). States should consider monitoring pollutant concentrations in all three tissues (fat, liver, and eggs) in addition to muscle tissue if resources allow. If residue analysis reveals the presence of high concentrations of any environmental contaminant of concern, the State should consider making the general recommendation to consumers to discard these three highly lipophilic tissues (fat, liver, and eggs) to reduce the risk of exposure particularly to many organic chemical contaminants.

To identify those freshwater turtle species with a known ability to bioaccumulate chemical contaminants in their tissues, the EPA Workgroup reviewed several studies that identified freshwater turtle species as useful biomonitors of PCBs (Bryan et al., 1987; Hebert et al., 1993; Helwig and Hora, 1983; Olafsson et al., 1983; 1987; Safe, 1987; and Stone et al., 1980), dioxins and dibenzofurans (Rappe et al., 1981; Ryan et al., 1986), organochlorine pesticides (Hebert et al., 1993; Stone et al., 1980), heavy metals (Helwig and Hora, 1983; Stone et al., 1980), and radioactive nuclides (cesium-137 and strontium-90) (Lamb et al., 1991; Scott et al., 1986). The turtle species used in these studies, the pollutants monitored, and the reference sources are summarized in Table 3-9.

Table 3-9. Summary of Recent Studies Using Freshwater Turtles as Biomonitors of Environmental Contamination

Species	Pollutant Monitored	Source
Snapping turtle (*Chelydra serpentina)*	PCBs Total DDT Mirex	Hebert et al., 1993
Snapping turtle (*Chelydra serpentina)*	PCBs	Olafsson et al., 1987 Olafsson et al., 1983
Snapping turtle (*Chelydra serpentina)*	PCBs	Safe, 1987
Snapping turtle (*Chelydra serpentina)*	PCBs	Bryan et al., 1987
Snapping turtle (*Chelydra serpentina)*	Dioxins and furans	Ryan et al., 1986
Snapping turtle (*Chelydra serpentina)*	PCBs Mercury Cadmium	Helwig and Hora, 1983
Snapping turtle (*Chelydra serpentina)*	PCDFs	Rappe et al., 1981
Snapping turtle (*Chelydra serpentina)*	Organochlorine pesticides DDE Dieldrin Hexachlorobenzene Heptachlor epoxide Mirex PCBs Cadmium Mercury	Stone et al., 1980
Yellow-bellied turtle (*Trachemys scripta)*	Cesium-137 Strontium-90	Lamb et al., 1991
Yellow-bellied turtle (*Trachemys scripta)*	Cesium-137 Strontium-90	Scott et al., 1986

PCBs = Polychlorinated biphenyls.
DDT = 1,1,1-Trichloro-2,2 bis(p-chlorophenyl)ethane.
PCDFs = Polychlorinated dibenzofurans.
DDE = 1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethylene.

State personnel, with their knowledge of site-specific fisheries and human consumption patterns, must be the ultimate judge of the turtle species selected for use in contaminant monitoring programs within their jurisdictions. Because several turtle species are becoming less common as a result of habitat loss or degradation or overharvesting, biologists need to ensure that the target species selected for the State toxics monitoring program is not of special concern within their jurisdiction or designated as a threatened or endangered species. For example, two highly edible turtle species, the Alligator snapping turtle (*Macroclemys temmincki*) and the Northern diamondback terrapin (*Malaclemys terrapin terrapin*) are protected in some States or designated as species of concern within portions of their geographic range and are also potential candidates for Federal protection (Sloan and Lovich, 1995). Although protected to varying degrees by several States, George (1987) and Pritchard (1989) concluded that the Alligator snapping turtle should receive range-wide protection from the Federal government as a threatened species under the Endangered Species Act. Unfortunately, basic ecological and life history information necessary to make environmental management decisions (i.e., Federal listing as endangered or threatened species) is often not available for turtles and other reptiles (Gibbons, 1988).

Several species of freshwater turtles already have been designated as endangered or threatened species in the United States including the Plymouth red-bellied turtle (*Pseudemys rubriventris bangsi*), Alabama red-bellied turtle (*Pseudemys alabamensis*), Flattened musk turtle (*Stemotherus depressus*), Ringed map (=sawback) turtle (*Graptemys oculifera*), and the Yellow-blotched map (=sawback) turtle (*Graptemys flavimaculata*) (U.S. EPA, 1994; U.S. Fish and Wildlife Service, 1994). In addition, all species of marine sea turtles including the Green sea turtle (*Chelonia mydas*), Hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempii*), Olive ridley sea turtle (*Lepidochelys olivacea*), Loggerhead sea turtle (*Caretta caretta*), and the Leatherback sea turtle (*Dermochelys coriacea*) have been designated as endangered (U.S. EPA, 1994; U.S. Fish and Wildlife Service, 1994).

3.4 ESTUARINE/MARINE TARGET SPECIES

EPA recommends that States collect **either** one shellfish species (preferably a bivalve mollusc) and one finfish species **or** two finfish species at each estuarine/marine screening site. In all cases, the primary criterion for selecting the target species is that it is commonly consumed. Ideally, one shellfish species and one finfish species should be sampled; however, if no shellfish species from the recommended target species list meets the primary criterion, EPA recommends that States use two finfish species selected from the appropriate regional estuarine/marine target species lists. If two finfish are selected as the target species, one should be a bottom-feeding species.

EPA recommends that, whenever practical, States use target species selected from fish and shellfish species identified in Tables 3-10 through 3-16 for the following specific estuarine/marine coastal areas:

- Northeast Atlantic region (Maine through Connecticut)—Table 3-10

Table 3-10. Recommended Target Species for Northeast Atlantic Estuaries and Marine Waters (Maine through Connecticut)

Family name	Common name	Scientific name
Finfish Species		
Anguillidae	American eel	*Anguilla rostrata*
Percichthyidae	Striped bass	*Morone saxatilis*
Pomatomidae	Bluefish	*Pomatomus saltatrix*
Sparidae	Scup	*Stenotomus chrysops*
Sciaenidae	Weakfish	*Cynoscion regalis*
Bothidae	Summer flounder	*Paralichthys dentatus*
	Four-spotted flounder	*Paralichthys oblongus*
Pleuronectidae	Winter flounder	*Pseudopleuronectes americanus*
	Yellowtail flounder	*Limanda ferruginea*
	American dab	*Hippoglossoides platessoides*
Shellfish Species		
Bivalves	Soft-shell clam	*Mya arenaria*
	Hard clam	*Mercenaria mercenaria*
	Ocean quahog	*Arctica islandica*
	Surf clam	*Spisula solidissima*
	Blue mussel	*Mytilus edulis*
Crustaceans	American lobster	*Homarus americanus*
	Eastern rock crab	*Cancer irroratus*

- Mid-Atlantic region (New York through Virginia)—Table 3-11

Table 3-11. Recommended Target Species for Mid-Atlantic Estuaries and Marine Waters (New York through Virginia)

Family name	Common name	Scientific name
Finfish Species		
Anguillidae	American eel	*Anguilla rostrata*
Ictaluridae	Channel catfish	*Ictalurus punctatus*
	White catfish	*Ictalurus catus*
Percichthyidae	White perch	*Morone americana*
	Striped bass	*Morone saxatilis*
Pomatomidae	Bluefish	*Pomatomus saltatrix*
Sparidae	Scup	*Stenotomus chrysops*
Sciaenidae	Weakfish	*Cynoscion regalis*
	Spot	*Leistomus xanthurus*
	Atlantic croaker	*Micropogonias undulatus*
	Red drum	*Sciaenops ocellatus*
Bothidae	Summer flounder	*Paralichthys dentatus*
Pleuronectidae	Winter flounder	*Pseudopleuronectes americanus*
Shellfish Species		
Bivalves	Hard clam	*Mercenaria mercenaria*
	Soft-shell clam	*Mya arenaria*
	Ocean quahog	*Arctica islandica*
	Surf clam	*Spisula solidissima*
	Blue mussel	*Mytilus edulis*
	American oyster	*Crassostrea virginica*
Crustaceans	Blue crab	*Callinectes sapidus*
	American lobster	*Homarus americanus*
	Eastern rock crab	*Cancer irroratus*

- Southeast Atlantic region (North Carolina through Florida)—Table 3-12

Table 3-12. Recommended Target Species for Southeast Atlantic Estuaries and Marine Waters (North Carolina through Florida)

Family name	Common name	Scientific name
Finfish Species		
Anguillidae	American eel	*Anguilla rostrata*
Ictaluridae	Channel catfish	*Ictalurus punctatus*
	White catfish	*Ictalurus catus*
Percichthyidae	White perch	*Morone americana*
	Striped bass	*Morone saxatilis*
Sciaenidae	Spot	*Leistomus xanthurus*
	Atlantic croaker	*Micropogonias undulatus*
	Red drum	*Sciaenops ocellatus*
Bothidae	Southern flounder	*Paralichthys lethostigma*
	Summer flounder	*Paralichthys dentatus*
Shellfish Species		
Bivalves	Hard clam	*Mercenaria mercenaria*
	American oyster	*Crassostrea virginica*
Crustaceans	West Indies spiny lobster	*Panulirus argus*
	Blue crab	*Callinectes sapidus*

- Gulf Coast region (west coast of Florida through Texas)—Table 3-13

Table 3-13. Recommended Target Species for Gulf of Mexico Estuaries and Marine Waters (West Coast of Florida through Texas)

Family name	Common name	Scientific name
Finfish Species		
Ictaluridae	Blue catfish	*Ictalurus furcatus*
	Channel catfish	*Ictalurus punctatus*
Ariidae	Hardhead catfish	*Arius felis*
Sciaenidae	Spotted seatrout	*Cynoscion nebulosus*
	Spot	*Leistomus xanthurus*
	Atlantic croaker	*Micropogonias undulatus*
	Red drum	*Sciaenops ocellatus*
Bothidae	Gulf flounder	*Paralichthys albigutta*
	Southern flounder	*Paralichthys lethostigma*
Shellfish Species		
Bivalves	American oyster	*Crassostrea virginica*
	Hard clam	*Mercenaria mercenaria*
Crustaceans	White shrimp	*Penaeus setiferus*
	Blue crab	*Callinectes sapidus*
	Gulf stone crab	*Menippe adina*
	West Indies spiny lobster	*Panulirus argus*

- Pacific Northwest region (Alaska through Oregon)—Table 3-14

Table 3-14. Recommended Target Species for Pacific Northwest Estuaries and Marine Waters (Alaska through Oregon)

Family name	Common name	Scientific name
Finfish Species		
Embiotocidae	Redtail Surfperch	*Amphistichus rhodoterus*
Scorpaenidae	Copper rockfish	*Sebastes caurinus*
	Black rockfish	*Sebastes melanops*
Bothidae	Speckled sanddab	*Citharichthys stigmaeus*
	Pacific sanddab	*Citharichthys sordidus*
Pleuronectidae	Starry flounder	*Platichthys stellatus*
	English sole	*Parophrys vetulus*
Salmonidae	Coho salmon	*Onchorhynchus kisutch*
	Chinook salmon	*Onchorhynchus tshawytscha*
Shellfish Species		
Bivalves	Blue mussel	*Mytilus edulis*
	California mussel	*Mytilus californianus*
	Pacific oyster	*Crassostrea gigas*
	Horseneck clam	*Tresus capax*
	Pacific littleneck clam	*Protothaca staminea*
	Soft-shell clam	*Mya arenaria*
	Manila clam	*Venerupis japonica*
Crustaceans	Dungeness crab	*Cancer magister*
	Red crab	*Cancer productus*

- Northern California waters (Klamath River through Morro Bay)—Table 3-15

Table 3-15. Recommended Target Species for Northern California Estuaries and Marine Waters (Klamath River through Morro Bay)

Family name	Common name	Scientific name
Finfish Species		
Triakidae	Leopard shark	*Triakis semifasciata*
Sciaenidae	White croaker	*Genyonemus lineatus*
Embiotocidae	Redtailed surfperch	*Amphistichus rhodoterus*
	Striped seaperch	*Embiotoca lateralis*
Scorpaenidae	Black rockfish	*Sebastes melanops*
	Yellowtail rockfish	*Sebastes flavidus*
	Bocaccio	*Sebastes paucispinis*
Bothidae	Pacific sanddab	*Citharichthys sordidus*
	Speckled sanddab	*Citharichthys stigmaeus*
Pleuronectidae	Starry flounder	*Platichthys stellatus*
	English sole	*Parophrys vetulus*
Salmonidae	Coho salmon	*Onchorhynchus kisutch*
	Chinook salmon	*Onchorhynchus tshawytscha*
Shellfish Species		
Bivalves	Blue mussel	*Mytilus edulis*
	California mussel	*Mytilus californianus*
	Pacific littleneck clam	*Protothaca staminea*
	Soft-shell clam	*Mya arenaria*
Crustaceans	Dungeness crab	*Cancer magister*
	Red crab	*Cancer productus*
	Pacific rock crab	*Cancer antennarius*

- Southern California waters (Santa Monica Bay to Tijuana Estuary)—Table 3-16.

Table 3-16. Recommended Target Species for Southern California Estuaries and Marine Waters (Santa Monica Bay to Tijuana Estuary)

Family name	Common name	Scientific name
Finfish Species		
Serranidae	Kelp bass	*Paralabrax clathratus*
	Barred sand bass	*Paralabrax nebulifer*
Sciaenidae	White croaker	*Genyonemus lineatus*
	Corbina	*Menticirrhus undulatus*
Embiotocidae	Black perch	*Embiotoca jacksoni*
	Walleye surf perch	*Hyperprosopan argenteum*
	Barred surfperch	*Amphistichus argenteus*
Scorpaenidae	California scorpionfish	*Scorpaena guttata*
	Widow rockfish	*Sebastes entomelas*
	Blue rockfish	*Sebastes mystinus*
	Bocaccio	*Sebastes paucispinis*
Pleuronectidae	Diamond turbot	*Hypsopetta guttulata*
	Dover sole	*Microstomus pacificus*
Shellfish Species		
Bivalves	Blue mussel	*Mytilus edulis*
	California mussel	*Mytilus californianus*
	Pacific littleneck clam	*Protothaca staminea*
Crustaceans	Pacific rock crab	*Cancer antennarius*
	Red crab	*Cancer productus*
	California rock lobster	*Panulirus interruptus*

Table 3-17. Sources of Information on Commercial and Sportfishing Species in Various Coastal Areas of the United States

Geographic area	Source
Atlantic Coast	National Marine Fisheries Service. 1987. *Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1986.* Current Fishery Statistics Number 8392. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Leonard, D.L., M.A. Broutman, and K.E. Harkness. 1989. *The Quality of Shellfish Growing Waters on the East Coast of the United States.* Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Nelson, D.M., M.E. Monaco, E.A. Irlandi, L.R. Settle, and L. Coston-Clements. 1991. *Distribution and Abundance of Fishes and Invertebrates in Southeast Estuaries.* ELMR Report No. 9. Strategic Assessment Division. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L. Andreasen. 1994. *Distribution and Abundance of Fishes and Invertebrates in Mid-Altantic Estuaries.* ELMR Rep. No. 12. NOAA/NOS Strategic Environmental Assessments Division, SIlver Spring, MD.
Gulf Coast	National Marine Fisheries Service. 1987. *Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1986.* Current Fishery Statistics Number 8392. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Broutman, M.A., and D.L. Leonard. 1988. *The Quality of Shellfish Growing Waters in the Gulf of Mexico.* Strategic Assessment Branch, National Oceanic and Atmospheric Administration, Rockville, MD.
	Monaco, M.E., D.M. Nelson, T.C. Czapla, and M.E. Patillo. 1989. *Distribution and Abundance of Fishes and Invertebrates in Texas Estuaries.* ELMR Report No. 3. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Williams, C.D., D.M. Nelson, M.E. Monaco, S.L. Stone, C. Iancu, L. Coston-Clements, L.R. Settle, and E.A. Irlandi. 1990. *Distribution and Abundance of Fishes and Invertebrates in Eastern Gulf of Mexico Estuaries.* ELMR Report No. 6. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Czapla, T.C., M.E. Patillo, D.M. Nelson, and M.E. Monaco. 1991. *Distribution and Abundance of Fishes and Invertebrates in Central Gulf of Mexico Estuaries.* ELMR Report No. 7. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Nelson, D.M. (editor). 1992. *Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries,* Volume I: Data Summaries. ELMR Rep. No. 10. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD.
West Coast	National Marine Fisheries Service. 1987. *Marine Recreational Fishery Statistics Survey, Pacific Coast, 1986.* Current Fishery Statistics Number 8393. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Leonard, D.L., and E.A. Slaughter. 1990. *The Quality of Shellfish Growing Waters on the West Coast of the United States.* Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.
	Monaco, M.E., D.M. Nelson, R.L. Emmett, and S.A. Hinton. 1990. *Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries.* Volume I: Data Summaries. ELMR Report No. 4. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, Rockville, MD.
	Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. *Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries.* Volume II: Life History Summaries. ELMR Report No. 8. Strategic Environmental Assessment Division, Rockville, MD.
	Jury, S.H., J.D. Field, S.L. Stone, D.M. Nelson, and M.E. Monaco. 1994. *Distribution and Abundance of Fishes and Invertebrates in North Atlantic Estuaries.* ELMR Rep. No. 13. NOAA/NOS Strategic Environmental Assessments Division, SIlver Spring, MD.

The seven separate regional lists of target species recommended by the EPA Workgroup for estuarine/marine ecosystems were developed because of differences in species' geographic distribution and abundance and the nature of the regional fisheries and were developed based on a review of species used in the following national monitoring programs:

- National Dioxin Study (U.S. EPA)
- Section 301(h) Monitoring Program (U.S. EPA)
- National Status and Trends Program (NOAA)
- National Study of Chemical Residues in Fish (U.S. EPA).

Because some of these programs identified some fish and shellfish species that are not of commercial, sportfishing, or subsistence value, several recent literature sources identifying commercial and sportfishing species were also reviewed (Table 3-17). Some sources included information on seasonal distribution and abundance of various life stages (i.e., adults, spawning adults, juveniles) of fish and shellfish species. This information was useful in delineating seven regional estuarine/marine areas nationwide. The EPA Workgroup also reviewed fish and shellfish species cited in State consumption advisories for estuarine/marine waters (Appendix B). Each of the final regional lists of target species has been reviewed by State, regional, and national fisheries experts.

Use of two distinct ecological groups of organisms (shellfish and finfish) as target species in estuarine/marine systems is recommended. This permits monitoring of a wide variety of habitats, feeding strategies, and physiological factors that might result in differences in bioaccumulation of contaminants. Estuarine/marine species used in several national contaminant monitoring programs are compared in Table 3-18.

3.4.1 Target Shellfish Species

Selection of shellfish species (particularly bivalve molluscs) as target species received primary consideration by the EPA Workgroup because of the commercial, recreational, and subsistence value of shellfish in many coastal areas of the United States. Bivalve molluscs (e.g., oysters, mussels, and clams) are filter feeders that accumulate contaminants directly from the water column or via ingestion of contaminants adsorbed to phytoplankton, detritus, and sediment particles. Bivalves are good bioaccumulators of heavy metals (Cunningham, 1979) and polycyclic aromatic hydrocarbons (PAHs) and other organic compounds (Phillips, 1980; NOAA, 1987) and, because they are sessile, they may reflect local contaminant concentrations more accurately than more mobile crustacean or finfish species.

Three bivalve species—the blue mussel (*Mytilus edulis*), the California mussel (*Mytilus californianus*), and the American oyster (*Crassostrea virginica*)—were recommended and/or used in three of the national monitoring programs. Two other bivalve species—the soft-shell clam (*Mya arenaria*) and the Pacific oyster (*Crassostrea gigas*)—were also recommended and/or used in two national programs. Although no bivalve species was identified by name in State fish and shellfish consumption advisories (Appendix B), seven coastal States issued advisories for unspecified bivalves or shellfish species that may have included these

and other bivalve species. All three species are known to bioaccumulate a variety of environmental contaminants (Phillips, 1988). The wide distribution of these three species makes them useful for comparisons within a State or between States sharing coastal waters (Figure 3-2). Because these three species meet all of the selection criteria, they are recommended as target species for use in geographic areas in which they occur.

In addition, several species of edible clams were added to the various estuarine/marine target species lists based on recommendations received from specific State and regional fisheries experts.

Crustaceans are also recommended as target species for estuarine/marine sampling sites. Many crustaceans are bottom-dwelling and bottom-feeding predator and/or scavenger species that are good indicators of contaminants that may be biomagnified through several trophic levels of the food web. Several species of lobsters and crabs have been recommended in one national monitoring program, and the Dungeness crab has been recommended in two national monitoring programs (Table 3-18). These crustaceans, although of fishery value in many areas, are not as widely distributed nationally as the three bivalve species (Figure 3-2). However, they should be considered for selection as target species in States where they are commonly consumed.

Only two crustaceans—the American lobster (*Homarus americanus)* and the blue crab *(Callinectes sapidus)*—were specifically identified in State advisories (RTI, 1993). However, seven coastal States reported advisories in estuarine/marine waters for unspecified shellfish species that may have included these and other crustacean species (Table 3-19). All of the shellfish species cited in State advisories are included as EPA-recommended target species on the appropriate estuarine/marine regional lists.

Table 3-19. Principal Estuarine/Marine Fish and Shellfish Species Cited in State Consumption Advisories [a,b]

Species group name	Common name	Scientific name	Number of States with advisories
Finfish			
Percichthyidae	**Striped bass**	***Morone saxatilis***	**5**
	White perch	***Morone americana***	**3**
Ictaluridae	**White catfish**	***Ictalurus catus***	**4**
	Channel catfish	***Ictalurus punctatus***	**5**
Anguillidae	**American eel**	***Anguilla rostrata***	**6**
Pomatomidae	**Bluefish**	***Pomatomus saltatrix***	**4**
Belonidae	Atlantic needlefish	*Strongylura marina*	1
Serranidae	**Kelp bass**	***Paralabrax clathratus***	**1**
Sciaenidae	Black croaker	*Cheilotrema saturnum*	1
	White croaker	***Genyonemus lineatus***	**1**
	Queenfish	*Seriphus politus*	1
	Corbina	***Menticirrhus undulatus***	**1**
Shellfish			
Crustaceans[c]	**American lobster**	***Homarus americanus***	**1**
	Blue crab	***Callinectes sapidus***	**3**

[a] Species in boldface are EPA-recommended target species for regional estuarine/marine waters (see Tables 3-10 through 3-16).

[b] Many coastal States issued advisories for fish and shellfish species and thus did not identify specific finfish and shellfish species in their advisories.

[c] Seven coastal States (American Samoa, California, Louisiana, Massachusetts, New Jersey, South Carolina, and Texas) report advisories for unspecified shellfish or bivalve species.

Source: RTI, 1993.

3.4.2 Target Finfish Species

Two problems are encountered in the selection of target finfish species for monitoring fish tissue contamination at estuarine/marine sites regionally and nationally. First is the lack of finfish species common to both Atlantic and Gulf Coast waters as well as Pacific Coast waters. Species used in several Federal fish contaminant monitoring programs are compared in Table 3-18. Members of the families *Sciaenidae* (seven species), *Bothidae* (two species), and *Pleuronectidae* (eight species) were used extensively in these programs. Bottom-dwelling finfish species (e.g., flounders in the families *Bothidae* and *Pleuronectidae*) may accumulate high concentrations of contaminants from direct physical contact with contaminated bottom sediments. In addition, these finfish feed on sedentary infaunal or epifaunal organisms and are at additional risk of accumulating contaminants via ingestion of these contaminated prey species (U.S. EPA, 1987a). For finfish species, two Atlantic coast species, spot (*Leiostomus xanthurus*) and winter flounder (*Pseudopleuronectes americanus*), are recommended and/or used in three of the national monitoring programs, and the Atlantic croaker (*Micropogonias undulatus*) is recommended and/or used in two national monitoring programs. Three Pacific coast species, Starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*), and Dover sole (*Microstomus pacificus*), are recommended or used in two of the national monitoring programs.

Second, because some estuarine/marine finfish species are highly migratory, harvesting of these species may be restricted to certain seasons because sexually mature adult fish (i.e., the recommended size for sampling) may enter the estuaries only to spawn. EPA recommends that neither spawning populations nor undersized juvenile stages be sampled in fish contaminant monitoring programs. Sampling of target finfish species during their spawning period should be avoided as contaminant tissue concentrations may decrease during this time (Phillips, 1980) and because the spawning period is generally outside the legal harvest period. **Note:** Target finfish species may be sampled during their spawning period if the species can be legally harvested at this time. Sampling of undersized juveniles of species that use estuaries as nursery areas is precluded by EPA's recommended monitoring strategy because juveniles may not have had sufficient time to bioaccumulate contaminants or attain harvestable size.

Because of these problems, the EPA Workgroup consulted with regional and State fisheries experts and reviewed the list of current State fish consumption advisories and bans to determine which estuarine/marine finfish species should be recommended as target species. As shown in Table 3-19, the largest number of States issuing advisories for specific estuarine and marine waters did so for the American eel (6), channel catfish (5), striped bass (5), bluefish (4), white catfish (4), and white perch (3). Several other estuarine/marine species were cited in advisories for one State each (Table 3-19). Many coastal States did not identify individual finfish species by name in their advisories (see Appendix B); however, almost all of the species that have been cited in State advisories are recommended as target species by EPA (see Tables 3-10 through 3-16).

These seven regional lists of recommended estuarine/marine target species are provided to give guidance to States on species commonly consumed by the general population. State personnel, with their knowledge of site-specific fisheries and human consumption patterns, must be the ultimate judge of the species selected for use in estuarine/marine fish contaminant monitoring programs within their jurisdiction.